(12) UK Patent Application (19) GB (11) 2 208 383 (13) A

(43) Date of A publication 30.03.1989

(21) Application No 8818067.4

(22) Date of filing 29.07.1988

(30) Priority data
(31) 0294087 (32) 31.07.1987 (33) CH

(71) Applicant
Stopinc Aktiengesellschaft

(Incorporated in Switzerland)

Zugerstrasse 76a, CH-6340 Baar, Switzerland

(72) Inventors
Klaus Muller
Hans Erich Hintermann
Gilbert Gindraux

(74) Agent and/or Address for Service
Kilburn and Strode
30 John Street, London, WC1N 2DD, United Kingdom

(51) INT CL⁴
B22D 37/00

(52) UK CL (Edition J)
C1J JX J1 J19 J2 J33 J4 J9
B3F FJGA

(56) Documents cited
None

(58) Field of search
UK CL (Edition J) B3F FJGA; C1J; F4B BD
INT CL⁴ B22D; C04B

(54) **Refractory wear parts for valves for metallurgical use**

(57) A method of treating a refractory wear part for a valve for metallurgical use includes subjecting that portion of the surface of the wear part which, in use, is subject to intense wear, to a laser beam and thereby melting the surface layer of the said portion and thus consolidating it.

GB 2 208 383 A

2208383

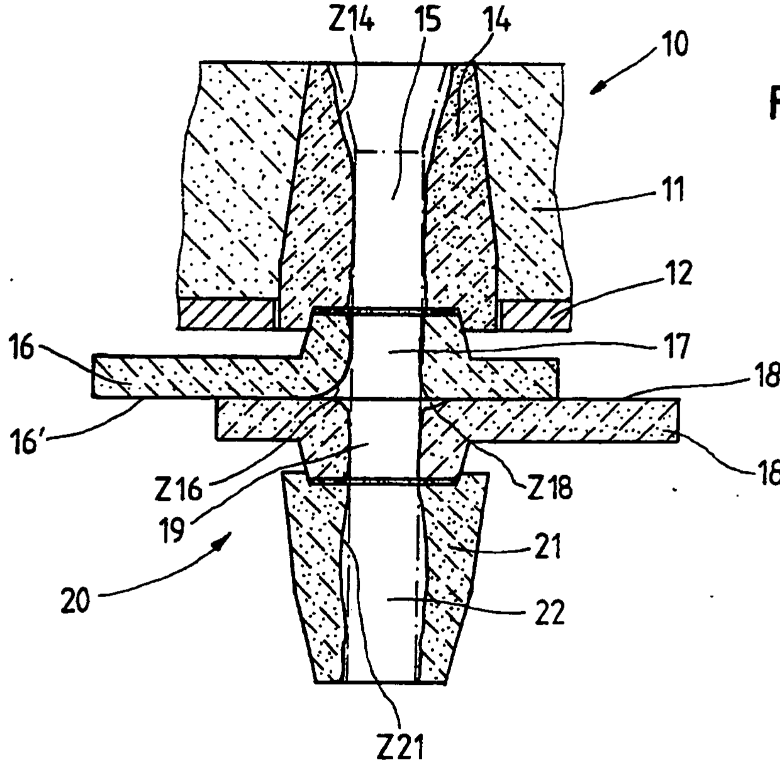


Fig.1

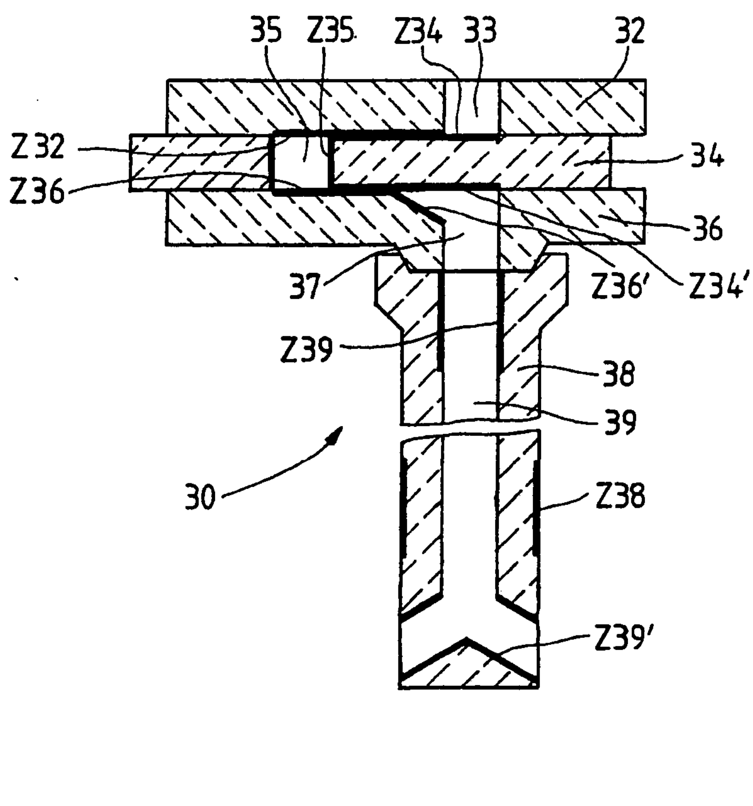


Fig. 2

Fig.3

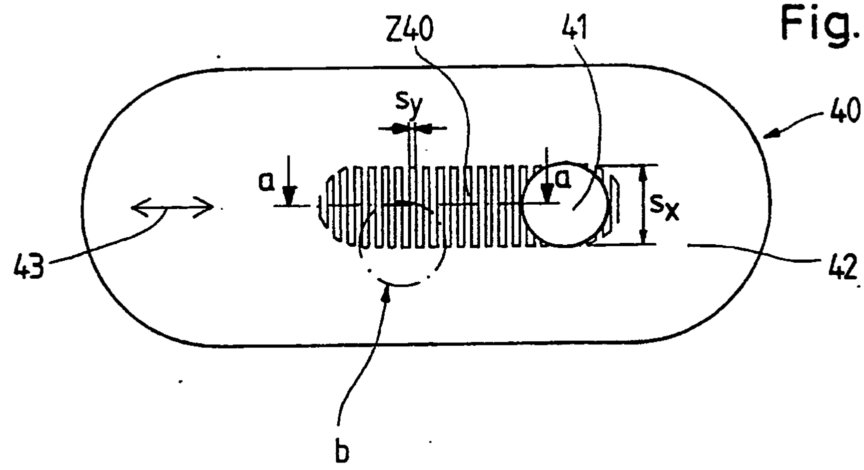


Fig.3a

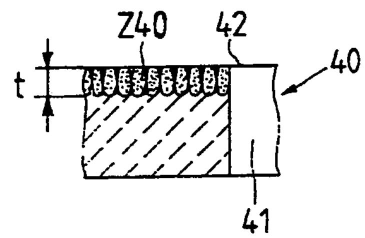


Fig.3b

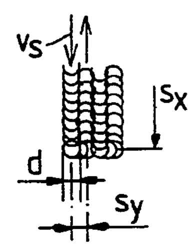


Fig.4

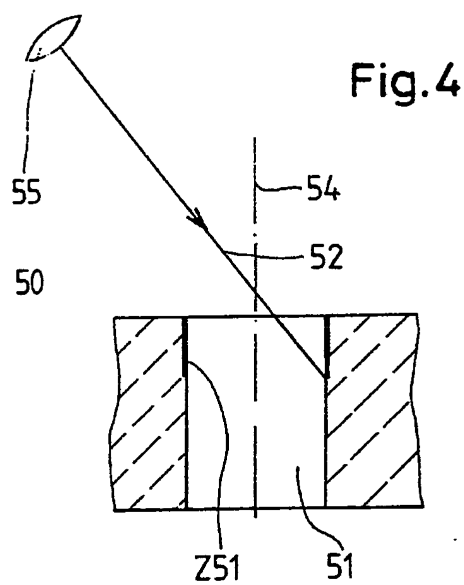


Fig.5

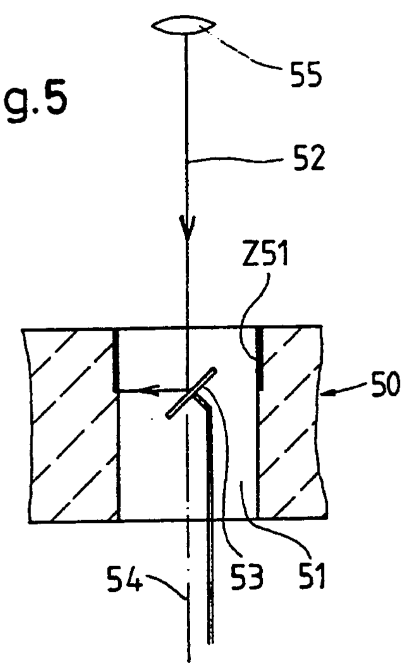


Fig.6

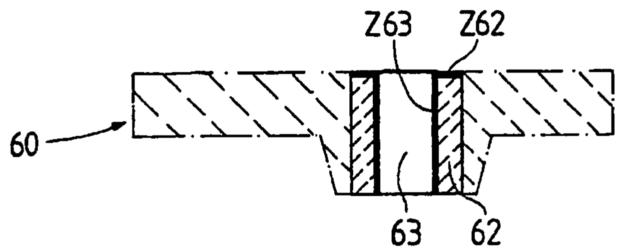
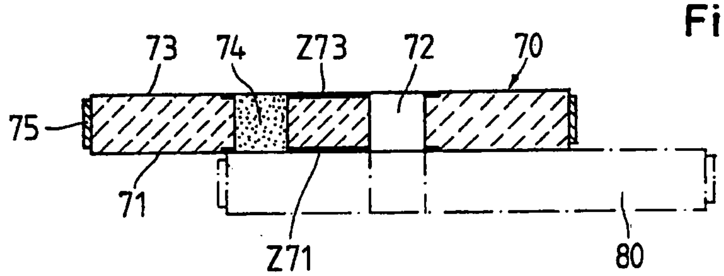


Fig.7



2208383

REFRACTORY WEAR PARTS FOR VALVES FOR METALLURGICAL USE

The invention relates to refractory wear parts for valves for metallurgical use, e.g. sliding gate valves or the like for use on metallurgical vessels. The term "wear part" embraces the components of such valves which, in use, are subjected to substantial wear, e.g. by virtue of their coming into contact with molten metal. Wear parts thus include, for instance inlet sleeves and outlet nozzles or sleeves and sliding plates and base plates for sliding gate valves.

Such wear parts commonly comprise fired, refractory, ceramic materials, such as zirconium oxide, boron nitride with a hexagonal lattice structure, aluminium titanate or high alumina-containing material. Refractory fire concrete, commonly with a high alumina-containing starting material, is also used.

In use, these wear parts are subject to very high temperatures and very severe wear by reason of their constant contact with the molten metal, e.g. steel, particularly at the surface zones in contact with the molten steel. These parts must thus be very frequently replaced.

In the sliding gate valve disclosed in DE-A-1937742, the surface of the flow opening and the seating surface of the sliding plate comprises a hard material, preferably a high-melting, oxidation-resistant metal silicite. This hard material is embedded in the form of an insert in the sliding plate, which is manufactured from conventional material, and is secured in position by means of an elastically extensible refractory cement. The manufacture and the

preliminary machining of the sliding plate for this insert is relatively expensive.

It is an object of the present invention to provide a simple and effective method of increasing the service life of wear parts of the type described.

According to the present invention a method of treating a refractory wear part for a valve for metallurgical use, particularly for use at the outlet of a metallurgical vessel, includes subjecting at least a portion of the surface of the wear part to a laser beam and thereby melting the surface layer of the said portion and thus consolidating it. In practice, that portion of the surface of the wear part which is subjected to the most intense wear is consolidated by the laser beam. The method of the present invention thus enables the service life of the wear part to be considerably increased without having to perform any complex or expensive processing. As a result of the method of treatment, the treated zone of the surface layer of the wear part is so consolidated, that is to say its surface texture is so changed, by the laser beam that the wear of the treated zone, which in use is in contact with molten metal, is significantly lower than in a comparable wear part which has not been so treated.

The laser beam may be incident directly on the zone to be treated or alternatively an additive material may be placed in position against the surface and the laser beam then applied whereby the additive material is also melted and becomes united with the surface layer. The additive material may be in pulverulent or particulate form and uniformly spread over the surface of the zone to be treated or it may be

in the form of sintered plates and in both cases it may comprise aluminium oxide, magnesium oxide, zirconium oxide or boron nitride.

It is preferred that the laser beam is passed over the portion of the surface which is to be treated with such an intensity and at such a speed that the surface layer of the zone to be treated is briefly heated to a temperature which is just above it melting temperature to a depth of up to 2mm.

If the zone to be treated is a flat surface, such as if the wear part is a sliding plate or base plate of a sliding gate valve, the laser beam is preferably moved back and forth across the said portion in a first direction and after each such movement is moved transversely thereto whereby the entire area of the said portion is exposed to the laser beam. Alternatively, the laser beam may be retained stationary and the wear part moved relative to it. Each transverse displacement of the laser beam or the wear part is preferably the same as or smaller than the diameter of the surface of the wear part which is melted by the laser beam.

If the wear part has a flow opening the treatment may comprise subjecting at least a part of the surface of the flow opening to the laser beam. One such method of treatment includes permitting the laser beam to be incident obliquely on the wall of the flow opening and rotating the wear part and/or the laser beam substantially about the axis of the flow opening and moving the wear part and/or the laser beam parallel to the said axis. An alternative method of such treatment includes directing the laser beam into the flow opening and deflecting it onto the wall of the flow opening by

means of a mirror within the flow opening and rotating the wear part and/or the mirror substantially about the axis of the flow opening and moving the wear part and/or the mirror substantially about the axis of the flow opening and moving the wear part and/or the mirror parallel to the said axis. Both of these methods enable simple and efficient treatment of the wall of the flow opening to be effected.

It is preferred that the laser source be arranged between 50 and 100mm away from the portion of the surface of the wear part on which the laser beam is incident. The precise spacing will depend substantially on the lens with which the laser is provided and the focal length of the lens. The speed of advance of the laser beam over the zone to be treated may be between 1 and 40mm/s, preferably between 1 and 10mm/s and the associated transverse displacements are preferably between 0.5 and 2mm and in this case the intensity of the laser beam is preferably between 1 and 50kW/cm^2 and the laser is preferably a CO_2 laser.

The wear parts may comprise a ceramic material of a type known per se, e.g. comprising predominantly (70-99%) alumina-containing material, predominantly (80-99%) zirconium oxide or predominantly (80-99%) magnesium oxide. The wear parts may also be of somewhat less high grade material, such as refractory fired concrete.

If the wear part is a sliding plate or a base plate of a sliding gate valve and the sliding surface of this plate is to be treated, it is found to be sufficient if the sliding surface is treated around the flow opening with the laser beam to a distance of

substantially half the diameter of the opening. Since the sliding surface of a plate may be roughened by the surface layer treatment it may be desirable to grind it after the treatment. Sliding plates and base plates are increasingly repaired after use by boring out the flow opening and embedding a high grade insert in the opening and the wear part may thus comprise a refractory sleeve insert adapted to be placed in the flow opening of such a plate, the method comprising treating the insert at at least one end surface thereof, that is to say the end surface which, in use, comes into direct contact with molten metal, and preferably also on the wall of its flow opening.

Valves for metallurgical use commonly include an inlet sleeve, an outlet sleeve and/or a pouring tube and all of these may be treated in accordance with the invention at at least one end, i.e. the upstream end, of the wall of the flow opening. It may also be desirable to treat a pouring tube over at least that portion of its external surface which, in use, is contacted by slag in a mould.

The present invention also embraces a wear part for a valve for metallurgical use which has been treated as described above, that is to say a wear part which has been subjected to a laser beam over at least a portion of its surface, that is to say over that portion of its surface which, in use, is in contact with molten metal, so as to melt or fuse its surface layer and thus consolidate it.

The invention also embraces a valve for metallurgical use, e.g. for use at the outlet of a metallurgical vessel, which incorporates one or more wear parts of the type referred to above. If the

sliding plate and/or the base plate has been treated it is preferred that the sliding surface thereof is so treated at least over that portion which comes into registry with the flow opening in the other said plate as the sliding plate moves from its fully open position to its fully closed position.

Further features and details of the invention will be apparent from the following description of certain specific embodiments which is given with reference to the accompanying diagrammatic drawings, in which:-

Figure 1 is a longitudinal sectional view of a known sliding gate valve for metallurgical use which has not been treated in accordance with the invention showing the wear pattern of the various refractory wear parts;

Figure 2 is a longitudinal sectional view of the refractory wear parts of a three-plate sliding gate valve which has been treated in accordance with the invention;

Figure 3 is a plan view of a sliding plate of a sliding gate valve;

Figure 3a is an enlarged scrap sectional view on the line a-a in Figure 3,

Figure 3b is an enlarged plan view of the portion within the circle b in Figure 3;

Figures 4 and 5 are schematic views of alternative methods of treating the surface layer of the flow openings in a wear part; and

Figures 6 and 7 are longitudinal sectional views of modified constructions of valve plates with a surface layer treatment in accordance with the invention.

The sliding gate valve 20 shown in Figure 1, of

which only the refractory wear parts 14, 16, 18 and 21 are shown is provided at the outlet 5 of a metallurgical vessel 10, of which only a portion is shown. The inlet sleeve 14 of the valve is embedded in the floor 11 of the vessel which has a steel shell 12. A refractory base plate 16 abuts the inlet sleeve 14 and has a flow opening 17 which is arranged concentrically with the opening 15 in the inlet sleeve 14. The valve 10 may be opened or closed in the usual manner by moving a refractory sliding plate 18, which is pressed against the base plate 16, by means of a mechanical drive, which is not illustrated. Connected to the sliding plate 18 is a refractory outlet sleeve 21. In the illustrated position of the valve 20 it is fully open. Such sliding gate valves are known per se and thus only the portions of concern for the invention are shown.

Refractory wear parts of valves for vessels containing molten metal are, as may be seen in Figure 1, exposed to the most intense wear at those regions which come into contact with the liquid metal. The intensity of the wear varies in accordance with the circumstances of use and depends substantially on the refractory composition of the individual wear parts, the composition of the metal to be poured and also on the pouring duration. In the case of the inlet sleeve 14, its flow opening 15 is typically worn in the upper region Z14. In the case of the valve plates 16 and 18, their flow openings 17 and 19 are frequently worn at the edges Z16 at the sides of the sliding surfaces 16' and 18'. The outlet sleeve 21 is subjected to the most severe wear, particularly in the region Z21 of the flow opening 22.

Only the refractory wear parts of concern for the present invention are shown in Figure 2 also. The valve 30 shown in Figure 2 is a three-plate sliding gate valve and is preferably used to regulate the molten metal flow rate from intermediate vessels in a continuous casting process. A portion of the surface layer of each wear part is treated in accordance with the invention. The refractory base plate 32, which in use is fixedly arranged at the outlet of an intermediate vessel and the lower refractory valve plate 36 are both in sliding contact with a refractory middle plate 34. By moving this middle plate 34 the valve may be moved into the completely open position or an intermediate throttled position or, as shown in Figure 2, the fully closed position. The flow opening 33 in the base plate 32 is arranged concentrically with the opening 37 in the lower plate 36. A pouring tube 38 with a flow opening 39 which is in registry with the opening 37 is commonly connected to the lower plate 36. This pouring tube 38, which, in use, is immersed in the molten metal melt in a mould (not illustrated), serves to shield the poured metallic stream from the atmosphere so that it does not absorb oxygen or other elements.

In accordance with the invention, each wear part is consolidated at its zone Z which is subjected to the most severe wear by a surface treatment with the aid of a laser. The upper and lower plates 32 and 36 are treated at the regions Z32 and Z36, respectively, which come into registry with the flow opening 35 in the middle plate 34, and the lower plate is additionally treated in the zone Z36' in the lateral extension of its flow opening. The middle plate 34 is treated in

the regions Z34 and Z34' which come into registry with the flow openings 33 and 37 in the upper and lower plates 32 and 36. The middle plate 34 is advantageously treated also in the wall region Z35 of its flow opening 35 because this opening is normally subjected to particularly severe wear. The pouring tube 38 is treated at least at the upper region Z39 of the surface of its flow opening. It is, however, preferably also treated in the region Z39' of the outlet and also externally at the region Z38 which, in use, is in contact with the very aggressive slag which floats on the melt in the mould.

It will be appreciated that the wear parts of the valve illustrated in Figure 1 could also be treated to be in accordance with the invention by consolidating the surface area Z of each of them with a laser.

The sliding plate 40 shown in Figure 3 is consolidated in the region Z40 by a surface layer treatment with the aid of a laser. The sliding plate 40 is movable, in use, over a predetermined distance from a fully closed position to a fully open position and vice versa. The flow opening of a fixed base plate in contact with the sliding surface 42 of the sliding plate 40 and thus the melt within the flow opening of this base plate contacts the region Z40 of the sliding plate 40. The surface layer of this region is melted in accordance with the invention by a laser beam to a predetermined depth t (as shown in Figure 3a), and thus consolidated. The depth t is in general between 0.5 and 2mm. When stationary the laser beam melts the surface over a diameter d and the region Z40 is consolidated by passing the laser beam over the region Z40 with an adjustable speed of advance v_s back and

forth by a distance s_x with a transverse displacement s_y between each back and forth movement. The back and forth movements are preferably transverse to the direction of movement 43 of the plate 40 but could be parallel to the direction of movement 43. Thus, after each back and forth movement by the distance s_x there is a transverse displacement s_y, also at a speed of advance v_s as is shown in Figure 3b. The transverse displacement s_y should be the same as or smaller than the diameter d melted by the laser beam. It is thus ensured that the entire region is melted and that no unmelted gaps are left between adjacent back and forth movements.

When treating the surface layer of a flow opening 51 in a wear part 50 with the aid of a laser, a laser beam 52 may be permitted to be incident obliquely on the surface of the bore, as shown in Figure 4. By virtue of rotary movement coupled with vertical movement s_y of the wear part 50 and/or of the laser source 55 about the axis 54 of the opening the laser beam may be guided over the entire area of the zone Z51 to fuse it. The vertical movement, either up or down, preferably occurs after each complete rotation of the wear part or of the laser source.

In the alternative method of treatment illustrated in Figure 5, the laser beam 52 is directed coaxially with the axis 54 of the bore onto a mirror 53, which is situated in the opening 51 and is advantageously at an angle of 45° to the axis 54, and is deflected by the latter perpendicularly onto the wall zone Z51 of the flow opening. To produce a predetermined speed of advance of the laser beam 52 on the wall of the flow opening of the workpiece 50 or the mirror 53 is again

rotated about the axis 54 of the bore and after each rotation moved through a height s_y. In this manner it is again ensured that the entire region of the treated wall zone Z51 of the flow opening is melted by the laser beam.

The laser beam is preferably arranged between 50 and 100mm away from the workpiece, depending on the focal length of the lens used in the laser source. The focal point should be situated approximately in the region of the surface layer to be treated. In practice, a speed of advance v_s between 1 and 10mm/s and associated transverse displacements s_y between 0.5 and 2mm at an intensity of the laser beam of between 1 and 50 kW/cm^2 have proved to be effective. The laser is preferably of CO_2 type.

Thus, for example, when treating a highly aluminous ceramic plate a laser beam was used which had an intensity of 11.5 kW/cm^2 and a melting diameter at the surface of 1.2mm and was guided over the surface with a speed of advance v_s of 4.7mm/s and transverse displacements of 1mm. The distance of the laser source from the workpiece was about 85mm.

In a different treatment of a highly aluminous ceramic material, the following parameters were selected:
Intensity 2.4 kW/cm^2, diameter 2.6mm, speed of advance 4.7mm/s, transverse displacement 1mm and distance of the laser source from the workpiece about 50mm.

Two different treatments of zirconium oxide plates were performed with the following parameters:
Intensities a) 11.5, b) 2.4 kW/cm^2; diameter a)1.2, b) 2.6mm; speed of advance a) 4.7, b) 29.5mm/s; transverse displacement a) 0.5, b) 0.5mm; distance of the laser

source from the workpiece a) 85, b) 50mm.

The invention may also be used in a similar manner for all other materials which are used in connection with valves on metallurgical vessels, such as magnesium oxide, refractory concrete, as is described for instance in DE-C 2624299 or on fibre-containing materials.

When conducting a surface layer treatment with the aid of a laser, in which an additive is spread or placed on the surface to be treated, the same parameters as described above may be used but preferably with about half the speed of advance as compared with the treatment without using an additive. A powder with a grain size between 0.02 and 0.2mm can be used as the additive which is spread uniformly over the surface or small sintered plates with a thickness up to a millimetre could be placed on the surface to be treated. After covering the surface layer to be treated with the additive material this is melted together with the surface layer by a laser beam in the same manner as shown in Figure 3 whereby a connection is produced between the additive material and the melted surface layer. When treating a flow opening wall with additive material, if a powder is to be used this can be glued to the wall before the treatment or a sintered bush can be fitted.

Valve plates of sliding gate valves are repaired ever more frequently after they have been used by embedding high grade inserts 62, as shown in Figure 6, in the worn flow opening of the valve plate 60. The invention has proved to be very effective with such inserts also by surface layer treating at least the region Z62, and preferably also the wall Z63 of the

flow opening.

Plates 70 (80), which are ground on both sides, as shown in Figure 7 are commonly used in sliding gate valves. After being worn on the one side 71 and at the one flow opening 72, such plates are turned over and the other side 73 and the flow opening 74 are then used. The flow opening 74 is initially filled with a plug which is removed when the plate 70 is turned over and inserted into the worn opening 72. In accordance with the invention the plate is consolidated by a laser beam on both sides, at least at the regions Z71 and Z73 which are subjected to the most severe wear. Both the bores could also be treated. The plate 70 is held together by a metal hoop 75 which surrounds it.

The invention may of course also be used on the wear parts of rotary sliding gate valves or other types of valve in a similar manner.

The sliding gate valves which have been described in detail above predominantly find application in the steel industry. The invention may, however, be used with other valves, such as stopper valves or rotary valves and also with wear parts of bypass valves. The refractory wear parts which are used therein are appropriately consolidated by the method of the present invention, at least at the zones subjected to the most severe wear.

CLAIMS

1. A method of treating a refractory wear part for a valve for metallurgical use which includes subjecting at least a portion of the surface of the wear part to a laser beam and thereby melting the surface layer of the said portion and thus consolidating it.

2. A method as claimed in claim 1 in which the said surface layer is melted by the laser beam after placing an additive material against the surface layer whereby the material is also melted and becomes united with the surface layer.

3. A method as claimed in claim 2 in which the additive material is uniformly spread over the said portion of the surface as a pulverulent material or placed in position in the form of sintered plates prior to the application of the laser beam.

4. A method as claimed in claim 2 or claim 3 in which the additive material comprises aluminium oxide, magnesium oxide, zirconium oxide or boron nitride.

5. A method as claimed in any one of the preceding claims in which the laser beam is passed over the said portion of the surface with such an intensity and at such a speed that the surface layer is heated to a temperature over its melting temperature to a depth of up to 2mm.

6. A method as claimed in claim 5 in which the said portion of the surface is substantially flat and the laser beam is moved back and forth across the said

portion in a first direction and after each such movement is moved transversely thereto whereby the entire area of the said portion is exposed to the laser beam.

7. A method as claimed in claim 6 in which the laser beam is moved transversely by a distance which is the same as or smaller than the diameter of the surface layer which is melted by the laser beam, when stationary.

8. A method as claimed in any one of the preceding claims in which the wear part has a flow opening at least a part of the surface of which is treated with the laser beam.

9. A method as claimed in claim 8 including permitting the laser beam to be incident obliquely on the wall of the flow opening and rotating the wear part and/or the laser beam substantially about the axis of the flow opening and moving the wear part and/or the laser beam parallel to the said axis.

10. A method as claimed in claim 8 including directing the laser beam into the flow opening and deflecting it onto the wall of the flow opening by means of a mirror within the flow opening and rotating the wear part and/or the mirror substantially about the axis of the flow opening and moving the wear part and/or the mirror parallel to the said axis.

11. A method as claimed in any one of the preceding claims in which the laser source is arranged between 50

and 100mm away from the portion of the surface of the wear part on which the laser beam is incident and the laser beam is moved over the said surface at a speed of between 1 and 40mm/s, the laser being of CO_2 type and the intensity of the laser beam being between 1 and 50 kW/cm^2.

12. A method as claimed in claims 6 and 11 in which the laser beam is moved transversely by a distance of between 0.5 and 2mm.

13. A method as claimed in any one of the preceding claims in which the wear part comprises a ceramic material comprising predominantly alumina-containing material, predominantly zirconium oxide, predominantly magnesium oxide or refractory fire concrete.

14. A method as claimed in any one of the preceding claims in which the wear part is a sliding plate or a base plate of a sliding gate valve with a sliding surface in which a flow opening is formed and in which the sliding surface is treated around the flow opening with the laser beam to a distance of substantially half the diameter of the opening.

15. A method as claimed in claim 14 in which the sliding surface of the plate is ground after the treatment with the laser.

16. A method as claimed in any one of claims 1 to 5 in which the wear part is a refractory sleeve insert adapted to be placed in the flow opening of a sliding plate or base plate of a sliding gate valve, the method

comprising treating the insert at at least one end surface thereof.

17. A method as claimed in one of claims 1 to 5 or 9 to 11 in which the wear part is an inlet sleeve or an outlet sleeve, the method comprising treating the wall of the flow opening at at least one end thereof with the laser beam.

18. A method as claimed in any one of claims 1 to 5 or 9 to 11 in which the wear part is a pouring tube, the method comprising treating the wall of the flow opening at at least one end thereof and/or the outer surface of the pouring tube in the region where, in use, it is contacted by slag in a mould.

19. A method of treating a wear part for a valve for metallurgical use substantially as specifically herein described with reference to any one of Figures 1 to 7.

20. A wear part for a valve for metallurgical use which has been treated as claimed in any one of the preceding claims.

21. A valve for metallurgical use incorporating one or more wear parts as claimed in claim 20.

22. A sliding gate valve as claimed in claim 21 in which the sliding plate and/ or the base plate has been treated at least over that portion of its sliding surface which comes into registry with the flow opening in the other said plate as the sliding plate moves from its fully open position to its fully closed position.

Published 1988 at The Patent Office. State House. 66 71 High Holborn. London WC1R 4TP. Further copies may be obtained from The Patent Office.